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Application of Finite Element Analysis Method to Investigate Effect of Blanking Process Variables on Sheet

Mr. Pankaj G. Dhoble[1], Dr. R. R. Deshmukh[2],Mr. Sushil D. Yeole[3]

(Assistant Professor, Department of Mechanical Engineering, MGM Polytechnic, Aurangabad, India) [1, 3]

(Professor, Department of Mechanical Engineering, MGM JNEC, Aurangabad, India)[2]

ABSTRACT: *The present work consist of general framework for numerical simulation of sheet metal blanking process using finite element method. Blanking consist of a metal forming operation characterized by complete metal separation. Experimental observations are shown that during shearing process large plastic deformation will generated in sheet, it should be considered during designing and manufacturing of blanking die. The work discuses some of the issues involved in blanking modeling and analyze influence of the clearance in Shear Stress & EQV Stress. The commercial finite element software tool ANSYS has been chosen to simulate blanking process.*

Keywords: *Deformation, Numerical Simulation, Blanking, FEA, FEM, EQV.*

I. Introduction

A blanking operation consists in cutting a sheet by subjecting it to shear stresses. The shearing process develops between a punch and a die and leads to the total rupture and deformation of the sheet. In these high productivity industries the components are obtained using high stroke rates. Punch and die geometry (i.e. punch and die corner radii), punch rate, lubrication, the clearance between the punch and the die (also called blanking clearance) and the properties of the metal sheet influence the shearing process. [1] D. Brokken and W.A.M. Brekelmans [5] have presented an elasto-plastic finite element model will be introduced, in which the extremely large deformations which occur are handled by an operator split arbitrary Lagrange±Euler method combined with remeshing. W.F. Fan, J.H. Li [9] introduced technical process of fine blanking with negative clearance and Gang Fang, Pan Zeng, Lulian Lou presented the punch–die clearance values for a given sheet material and thickness are optimized, using the finite element technique and Cockroft and Latham fracture criterion. Thomus Pyttle and Ralf John [6] who assume that numerical model validate by experiment which illustrate the effect some process parameters on blanking forces and edge quality based on fracture mechanism. Miguel vaz Jr and Jose Divo Bressan [8] presented a general framework for numerical simulation of blanking processes using finite elements. A numerical approach to the problem requires a comprehensive finite element modelling due to the diversity of physical phenomena involved, such as large plastic deformation, material failure and coupled heat transfer.

The present work discuses some computational issues on modeling blanking process and investigate the effect of the clearance on Sheet, during penetration phase of cutting process. Simulation aims at application to manufacture sheet metal components at Indo- German Tool Room, Aurangabad.

II. Objectives

Find out actual stress concentration on medium carbon steel sheet where actual shearing takes place (Shear stress and Equivalent stress) under the influence of vertical load on punch is an important objective in Blanking dies. [8]

III. Finite Element Analysis

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition. [2, 5]

There are generally two types of analysis that are used in industry: 2-D modeling, and 3-D modeling. While 2-D modeling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results. 3-D modeling, however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively. Within each of these modeling schemes, the programmer can insert numerous algorithms (functions) which may make the system behave linearly or non-linearly. Linear systems are far less complex and generally do not take into account plastic deformation. Nonlinear systems do account for plastic deformation, and many also are capable of testing a material all the way to fracture.

3.1 Material Properties

Material properties (Young's modulus, Poisson's ratio, the density, & if applicable, coefficients of expansion, friction, thermal conductivity, damping effect, specific heat etc.) will have to be defined. In this study two different materials are used HcHcr for Punch, Die and Medium carbon steel for sheet material properties are shown below.

HcHcr		Medium Carbon Steel	
DENSITY	7750 kg	DENSITY	7750 kg
YOUNG's MODULUS	21000 Mpa	YOUNG's MODULUS	1.93 3E+05
POISSIONS RATIO	0.31	POISSIONS RATIO	0.31
BULK MODULUS	1.842 1E+10	BULK MODULUS	1.69 3E+11
SHEAR MODULUS	8.015 3E+09	SHEAR MODULUS	7.366 4E+10
TENSILE YEILD STRENGTH	1650MPa	TENSILE YEILD STRENGTH	180 MPa
COMP. YEILD STRENGTH	1650MPa	COMP. YEILD STRENGTH	180 MPa
TENSILE ULTIMATE STRENGTH	1990 Mpa	TENSILE ULTIMATE STRENGTH	300 Mpa
COMP. ULTIMATE STRENGTH	2000 Mpa	COMP. ULTIMATE STRENGTH	300 Mpa

Table.1 Material properties (Punch, Die and Sheet)

3.2 Constraints and Loads

Models were constrained in all directions at the nodes on sheet. Since this study was aimed at investigating deformation on punch, die, forces of 22000 N were applied axially (AX). The analysis was performed for each Punch and sheet by means of the Ansys Workbench software program.

IV. Methodology Of Work

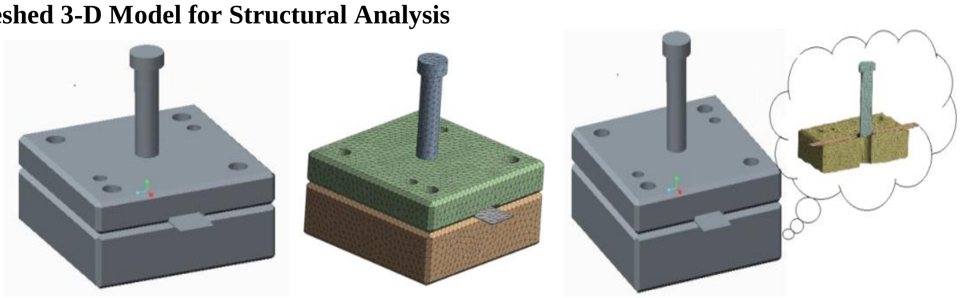
Step 1: Concept Design

Collection of information related to stress distribution from various literatures on finite element analysis of blanking process [6]

Step 2: Cad 3-D Model of Punch and Die Assembly

The attractive feature of finite element is the close physical resemblance between the actual structure and its finite element model. Excessive simplifications in geometry will inevitably result in considerable inaccuracy. The model is not simply an abstraction; therefore, experience and good engineering judgment are needed to define a good model. [7] Whether to perform a three-dimensional (3-D) finite element model for the study is a significant query in FEA. It is usually suggested that, when comparing the qualitative results of one case with respect to another, a 2-D model is efficient ,although the time needed to create finite element models is decreasing with advanced computer technology, there is still a justified time and cost savings when using a 2-D model over 3-D, when appropriated. However, 2-D models cannot simulate the 3-D complexity within structures. In 3-D analysis; the stress and strain condition can be evaluated in all three axes (x, y, and z). The first step in FEA modelling is to represent the geometry of interest in the computer. A blanking tool with Punch and die was modelled on a personal computer, using a 3-D program (PTC Creo 2.0, Parametric Technology Corporation, USA) and UG Nx-8.0 (Unigraphix, Siemens Technologies, France). After creation of complete Nine CAD assemblies of punch & die with different clearances on punch with respect to sheet thickness, the model of assembly is transformed into STEP (Standard for the Exchange of Product model data) file format which is easily imported CAD data into FEA environment. We are using ANSYS program for meshing & structural analysis of 3-D model of blanking die to get required results.

Step 3: Meshed 3-D Model for Structural Analysis



(A) (B) (C)

Fig.1 A. 3-D Model, B. Meshed, Model C. Slicing

3.1 Slicing of 3-D model

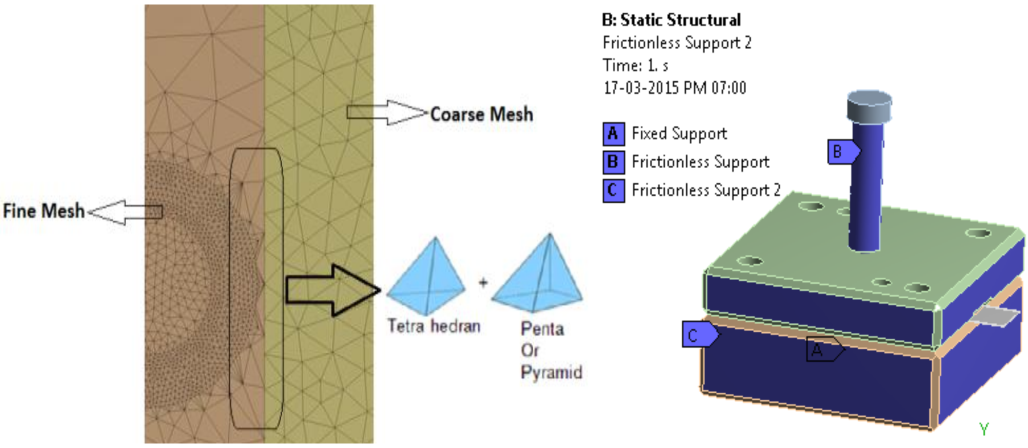
The Slice feature improves the usability of Design Modeller as a tool to produce sweep able bodies for hex meshing. As with the Slice Material operation, the Slice feature is only available when the model consists entirely of frozen bodies. If you need to perform slicing in your model, it is better to do it before assigning loads and boundary conditions in the ANSYS Mechanical application. With the help of slicing we can able to keep control over number of nodes in model. Using slicing tool we had done slicing in assembly model of Blanking setup. Because of slicing we can do hybrid mesh i.e. combination of Tetrahedral & Pyramid elements at interface of critical location. Also with the help of slicing we can achieve combination of very fine mesh to coarse mesh in small regions. With the help of slicing we can see the inside stresses very easily by hiding the other sliced part of CAD geometry. Slicing made visualization easy.

3.2 Elements and nodes

The models were meshed with 3-D tetrahedron and Pyramid elements. A refinement mesh was generated around the punch. Also hybrid mesh is used to get refinement on the sheet where the actual contact between punch and sheet, Hybrid mesh is as shown below, it is combination of Tetrahedral & Pyramid elements.

3.3 Boundary Conditions

Total assembly contains Punch; Die and Sheet in that Die is fixed at bottom as shown below. Fixed surface is shown in blue colour. Total assembly is as shown below



(A) (B)

Fig.2 A. Elements used in meshing, B. Boundary Conditions

3.4 Loading Conditions

Total assembly is fixed at bottom and vertically downward force of 22000N is applied on punch as shown in below figure

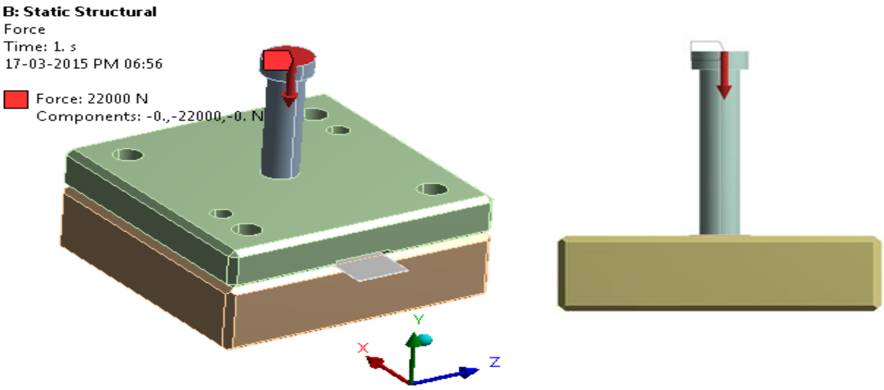


Fig.3 Loading Condition

Step 4: Finite element Analysis (FEA) Results

4.1 Assembly Model – A

Sheet thickness 0.25mm, Blanking punch Ø 9.96 (Clearance 5 % of sheet thickness)

In all loading conditions, the highest deformation on sheet at the region where actual force is applied and on die contact area of punch and die with sheet.

4.2 Assembly Model – B

Sheet thickness 0.25mm, Blanking punch Ø 9.95 (Clearance 10 % of sheet thickness)

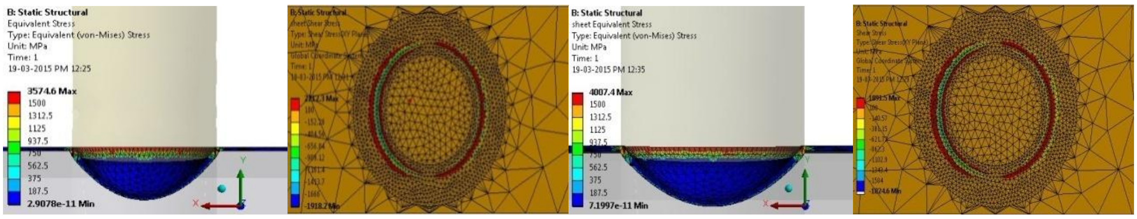


Fig.4 FEA Results for EQV and Shear Stress (Assembly Model-A and B)

4.3 Assembly Model – C

Sheet thickness 0.25mm, Blanking punch Ø 9.94 (Clearance 15 % of sheet thickness)

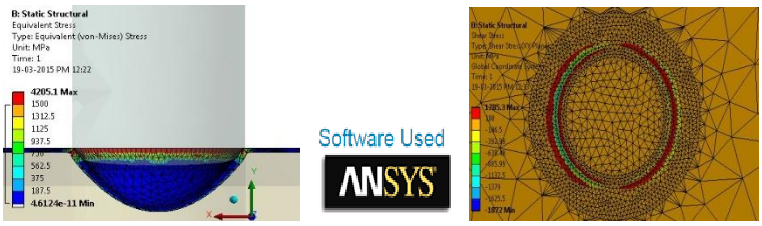


Fig.5 FEA Results for EQV and Shear Stress (Assembly Model-C)

4.4 Assembly Model – D

Sheet thickness 0.5mm, Blanking punch Ø 9.89 (5 % of sheet thickness)

4.5 Assembly Model – E

Sheet thickness 0.5mm, Blanking punch Ø 9.88 (10 % of sheet thickness)

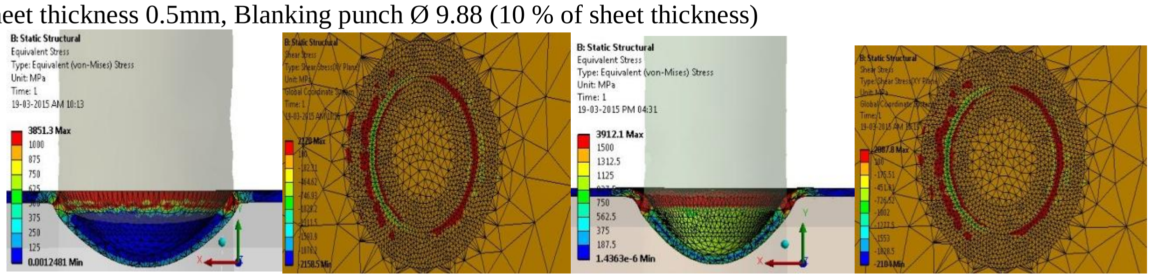


Fig.6 FEA Results for EQV and Shear Stress (Assembly Model-D and E)

4.6 Assembly Model – F

Sheet thickness 0.5mm, Blanking punch Ø 9.87 (15 % of sheet thickness)

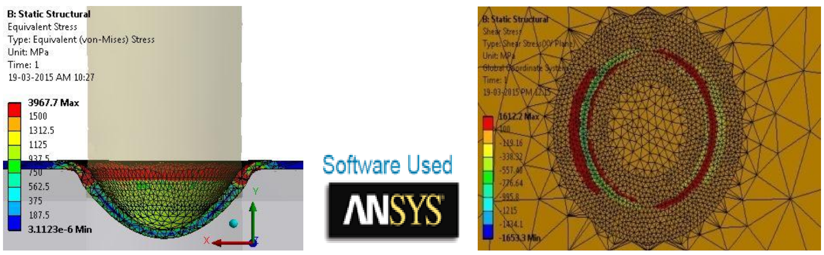


Fig.7 FEA Results for EQV and Shear Stress (Assembly Model-F)

4.7 Assembly Model – G

Sheet thickness 0.6mm, Blanking punch Ø 9.85 (5 % of sheet thickness)

4.8 Assembly Model – H

Sheet thickness 0.6mm, Blanking punch Ø 9.84 (10 % of sheet thickness)

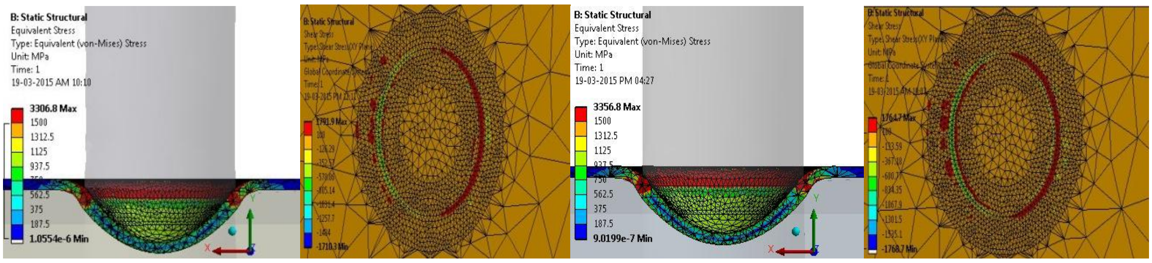


Fig.8 FEA Results for EQV and Shear Stress (Assembly Model-G and H)

4.9 Assembly Model – I

Sheet thickness 0.6mm, Blanking punch Ø 9.83 (15 % of sheet thickness)

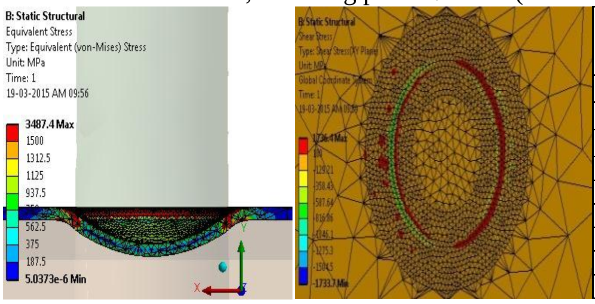


Fig.9 FEA Results for Stresses (Assembly Model-I)

Sr No	Punch Diameter	Clearance	EQV Stress N/mm^2	Shear Stress N/mm^2
1	Ø9.96	5%	3574.6	2212.3
2	Ø9.95	10%	4007.4	1891.5
3	Ø9.94	15%	4205.1	1785.3
4	Ø9.89	5%	3851.3	2120
5	Ø9.88	10%	3912.1	2087.8
6	Ø9.87	15%	3967.7	1612.2
7	Ø9.85	5%	3304.8	1791.9
8	Ø9.84	10%	3356.8	1764.7
9	Ø9.83	15%	3407.4	1736.4

Table 2 Combined Results

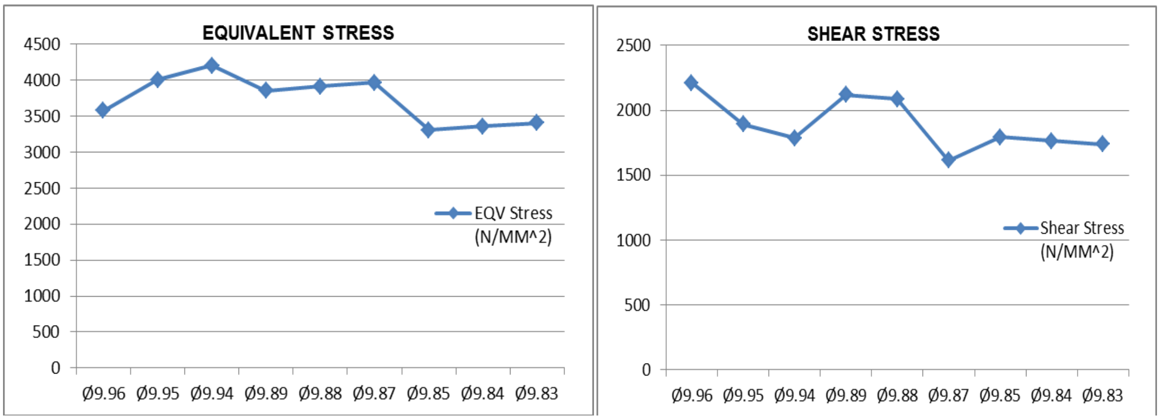


Fig.10 Graph for EQV Stress and Shear Stresss

V. CONCLUSION

This works discusses some aspects of numerical modeling of blanking process. The numerical FEA simulation shows the maximum shear stresses and EQV Stress occur near the punch corner ranging from 1612.2 N/mm^2 to 2212.3 N/mm^2 and 3306 N/mm^2 to 4205.1 N/mm^2. These values increase for greater frictional coefficient. The blanking process can be considered as cold working process due to the maximum temperature of 365 K (92˚ C) Attained in the sheet shear region.

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